FRONTIERS IN SOLID STATE LIGHTING

NEXT-WAVE LIGHTING TECHNOLOGIES

SOLID STATE LIGHTING WILL PROFOUNDLY CHANGE BUILDINGS … AND BENEFIT AMERICANS.

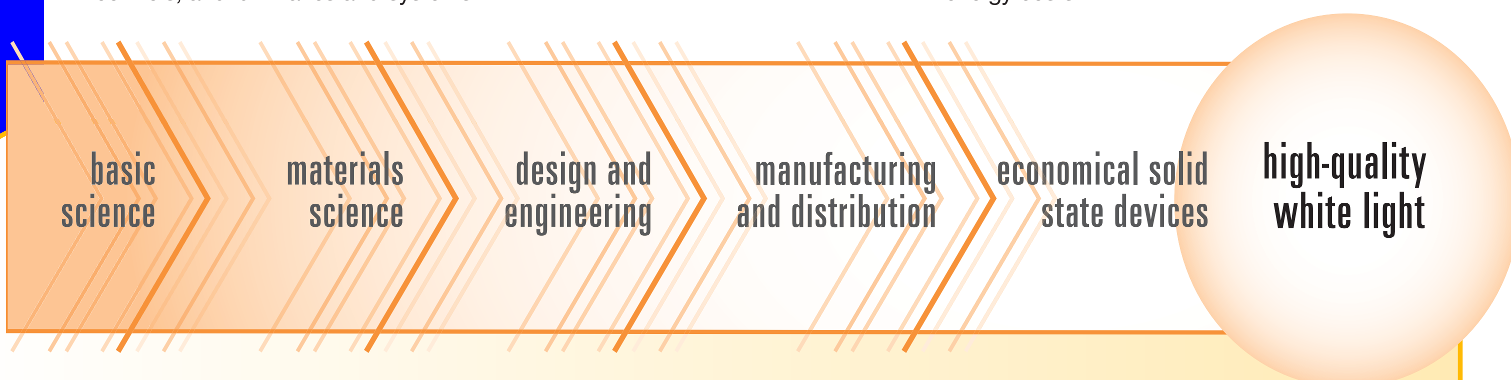
With advanced lighting systems, tomorrow's commercial builders can provide unprecedented levels of comfort and productivity for occupants, while reducing energy use and costs. In a two-year effort, 200 lighting industry leaders — from 175 manufacturing, professional, academic, government, and research organizations — produced *Vision 2020: The Lighting Technology Roadmap.* The roadmap defines technology development strategies that can have great impacts on the future of lighting.

The *Vision* — facilitated by the U.S. Department of Energy — advocates the development of advanced source and ballast technologies, intelligent controls, and luminaries and systems that will enhance the quality, flexibility, and cost effectiveness of light delivery. One of the high-priority R&D opportunities cited in the *Vision* is solid state lighting.

In the next few decades, general illumination technology will undergo a remarkable transformation. Just as transistors replaced vacuum tubes 50 years ago, and just as flat panel displays are now replacing CRT monitors and televisions, solid state lighting will likely take the place of incandescent and fluorescent lamps used for applications in general illumination.

Semiconductor-based products have proven far more compact, portable, powerful, and affordable than the "glass envelope" products they supplanted. They have been key enabling technologies, catalyzing new products and fast-growth industries, as seen most dramatically in the ongoing leaps in computing speed and power made possible by the transition from vacuum tubes to microprocessors.

Many believe that solid state technology has similar potential to radically change the future of general lighting. For example, "intelligent" lighting environments could respond to changing activities and needs through variable spectrum and intensity. Expected benefits include more responsive, comfortable, and productive building environments, coupled with substantial savings in energy costs.



RESEARCH HURDLES ARE SIGNIFICANT . . .

Achieving high-quality white light — from efficient, affordable solid state devices — will require extensive multi-disciplinary research and development. Scientists and engineers must gain a deeper understanding of the fundamentals of how light is produced in semiconductors. They must develop improved capabilities for intelligently selecting appropriate substrates and host materials for different applications. They also must find ways to increase the efficiency of light extraction for solid state devices, and to improve color selectivity and stability. Advances in physics, chemistry, materials science, and engineering, as well as manufacturing and distribution, will be essential in meeting these and other core challenges.

. . . AND POTENTIAL RETURNS ARE TREMENDOUS.

With accelerated research on compound semiconductors and other enabling technologies, solid state technologies are expected to become increasingly attractive for general illumination applications in coming decades. Breakthroughs in price and performance will speed the penetration of these technologies into the marketplace. If these breakthroughs can be achieved, cumulative energy savings between now and 2020 could exceed 14 quads of primary energy — translating to cost savings of more than $98 billion. Maintaining technology leadership in the U.S. will yield global market opportunities and high-technology jobs, as well as greater institutional strength in science education and research.

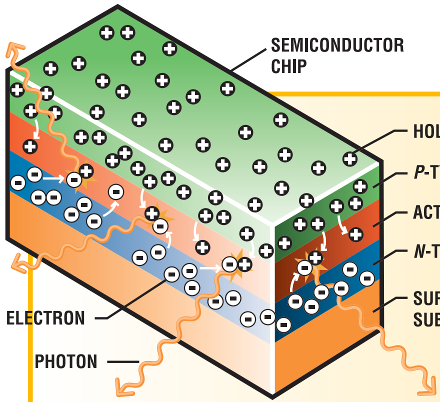
No other single lighting technology offers so much potential to conserve precious electricity. Electric lighting consumes about 20 percent of the electricity used in U.S. buildings. Solid state technologies have the potential to more than double the efficiency of general lighting systems in coming decades, conserving enough electricity to power the states of Arizona, Colorado, and Mississippi. These energy savings could reduce electricity bills by $98 billion cumulatively over the next 20 years, and significantly reduce the number of new power plants that must be built.

Yet major research challenges must be addressed before the promise of solid state lighting is realized in general illumination. While solid state products are already demonstrating strong performance and market growth in signaling and display applications, broad commercial applications in general illumination are not projected to command a significant market share for a decade or more.

The challenge is to develop high-power devices that emit high-quality white light, while meeting targets for efficiency, longevity, manufacturability, and — most important — cost.

This challenge is not trivial. It is of interest to multiple sectors of the lighting industry, as well as to U.S. government agencies, including the Departments of Energy, Defense, and Commerce. Focused, multi-disciplinary investment by both government and industry will accelerate progress, helping the nation realize the energy conservation and environmental benefits of solid state lighting, and positioning U.S. companies for technology leadership in global markets for new products, systems, and services that are projected to exceed $50 billion by 2020.

Private-public partnerships have been instrumental to U.S. leadership in such technologies as semiconductors and advanced batteries. Collaborative, cost-shared research through Sematech, for example, made possible the computational capabilities that are taken for granted today, spurring growth across multiple industries. Similarly, collaborative research can leverage the strengths of the public and private sectors — including the capabilities of leading universities and National Laboratories — in addressing the formidable challenges ahead in solid state lighting research.



Solid state lighting creates light without heat *– which means far less energy loss. At the heart of a solid state light is a sandwich of semiconductor layers, built on a substrate. Electrons released from the negative* n*-type layer combine with holes from the positive* p*-type layer. Electron-hole pairs may join to produce a photon, which is emitted from the active layer.*

Solid state technologies will change the way lighting systems — and buildings — are designed and used. *It will be possible to mount solid state devices in any pattern or shape on floors, walls, ceilings, or furniture, providing either point or diffused light that can be tuned to the shade or intensity desired by the occupants. Tomorrow's lighting systems will also become part of the information revolution. For instance, thin "films" of solid state light could be applied to almost any surface, even within windows, to provide both light and communication displays.*

Vision 2020
THE LIGHTING TECHNOLOGY ROADMAP

The lighting industry's vision for 2020 — *The Lighting Technology Roadmap* — cited the promise of solid state lighting. The roadmap, facilitated by the U.S. Department of Energy, sets a framework for research objectives.

About the cover
Solid state lighting opens bold new possibilities for designing spaces and products. Lighting and information displays can be flexibly integrated with surfaces, enabling (on cover) heads-up displays on car windshields; ultra-thin, configurable computer screens; illuminated glass floors; and "curtains" of light for theater backdrops or other architectural applications (lower right corner).

Conceptual images courtesy of Sheila Kennedy and Fellows of Harvard University; Mark Thompson, University of Southern California; and Universal Display Corporation.

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